Title of the Invention

METHOD OF DETECTING PARTICLES AND A PROCESSING APPARATUS USING THE SAME

Background of the Invention

The present invention relates to a method for forming a thin film, a circuit pattern, and so forth as desired on a semiconductor substrate using plasma, such as etching, sputtering, and CVD, and an apparatus using the method. The invention particularly relates to: a method of processing a sample while detecting fine particles (contaminants) floating in an interior of a semiconductor manufacturing apparatus such as a plasma processing apparatus; a processing apparatus with a particle detector; and a contaminant control system for controlling the detected contaminants. More specifically, the invention relates to a technology for measuring a contaminant occurrence state by measuring on real-time basis the contaminants occurring in a processing chamber in the course of forming the thin film, the circuit pattern, and so forth using the plasma processing technology.

Conventionally, processing apparatuses using plasma, such as an etching apparatus, have widely been used for manufacturing semiconductors and liquid crystal display device substrates.

In plasma etching processing performed by the processing apparatus using plasma, for instance, reaction products generated by the etching reaction are deposited on a wall or electrodes of a plasma chamber, and the reaction products are stripped off in the course of time to become floating contaminants.

The floating contaminants which have been trapped by plasma before the start of etching and during the etching fall on a substrate for semiconductor processing when the discharge is stopped, and adhere to the substrate. The contaminants adhered to the substrate cause etching defects such as non-aperture, bad circuit characteristics, and bad pattern appearance. Ultimately, the contaminants are responsible for reduction in yield of semiconductor elements and deterioration in reliability of the elements.

Then, as a device for performing in-situ measurement of the contaminants floating in a plasma processing apparatus, there has been proposed a device for detecting fine particles in the vicinity of a wafer in a semiconductor device manufacturing apparatus. This detecting device comprises a detector including a light transmitter for transmitting a light beam to be emitted across a measurement volume; and an optical system for condensing scattered light from the measurement volume to direct the light to a photodetector, the detector being

adapted to generate a signal representing the intensity of the light directed to the photodetector. This detecting device further comprises a signal processing means including a pulse detector interconnected with the photodetector so as to analyze the signal from the photodetector and detect a pulse in the signal from the photodetector; and an event detector for identifying a series of pulses which is associated with the fine particles and is generated by the scattered light from the particles due to a plurality of times of the light beam irradiations performed during the period when the fine particles move in the measurement volume (see, for example Japanese Patent Laid-open No. 10-213539).

However, the detector disclosed in Japanese Patent Laid-open No. 10-213539 observes a partial region of the wafer using fixed laser light, and it has a difficulty in measuring floating contaminants present in the plasma processing chamber.

Thus, as a method and a device for performing in-situ measurement of contaminants floating in the plasma processing chamber over whole surface of a wafer, a particle monitoring method and a work processing device have been proposed. This technique is capable of emitting laser light vertically, horizontally, or vertically and horizontally in the processing chamber and detecting the

laser light scattered from the contaminants in the processing chamber to monitor contaminants in the processing chamber using intensity of detected laser light on real time basis (see, for example, Japanese Patent Laid-open No. 9-243549).

Also, as a method for in-situ measuring contaminants floating in a plasma processing apparatus, a particle detection method for detecting exhausted contaminants by providing a particle detector in an exhaust passage of a vacuum processing device has been proposed (see, for example, Japanese Patent Laid-open No. 6-148059).

However, in the method disclosed in Japanese Patent Laid-open No. 6-148059, a particle detector 11c is disposed downstream of an exhaust passage 8 connected to an outlet 20 and a butterfly valve 9 as shown in, for example, Fig. 13, and the contaminant measurement is performed remote from the vacuum chamber and in an atmosphere different form that of the processing chamber. Therefore, it is difficult to correctly distinguish the contaminants in the processing chamber from the contaminants deposited and stripped in the exhaust passage for the measurement, and, under a vacuum of several Pa, the contaminants are hardly brought to a sensor provided in the exhaust passage so that the number of contaminants reaching to the exhaust passage is reduced, resulting in a decreased contaminant capture rate and

deteriorated detection accuracy.

Then, in order to improve contaminant detection accuracy as compared to that of the contaminant detection in the exhaust passage, a particle detection device including an exhaust spare room provided at an outlet formed in a vacuum chamber; an exhaust passage connected to the exhaust spare room; a laser light emitter for irradiating the exhaust spare room with laser light for detection; and a photodetector for detecting light reflected by contaminants has been proposed (see, for example, Japanese Patent Laid-open No. 9-203704).

However, in the method and device disclosed in Japanese Patent Laid-open No. 9-243549, a particle detector 11b is disposed at a measurement window 10 for measuring a plasma generating space 13 which is above a substrate in a processing chamber, as shown in, for example, Fig. 14. Therefore, the measurement window 10 for detecting the laser emission and the scattered light from contaminants is exposed to the plasma generating space, and film deposition and etching on the measurement window are undesirably occur due to reaction products generated by plasma and etchant, thereby causing fogging on the measurement window to deteriorate the detection sensitivity.

Also, the device disclosed in Japanese Patent Laid-open No. 9-203704 requires the exhaust spare room at the

outlet formed in the vacuum chamber in addition to the processing chamber, the number of the contaminants arriving at the exhaust spare room is small as is the case with the exhaust passage, and only one point extending from the center axis on the exhaust passage is subjected to the laser light detection. Therefore, problems of an insufficient contaminant capture rate and insufficient detection accuracy have been detected with this device.

Summary of the Invention

An object of the present invention is to provide a method of processing a sample while suppressing film deposition generated during plasma processing and fogging on a measurement window caused by etching to stably detect floating contaminants in a processing chamber with an improved contaminant capture rate as well as an apparatus using the method.

Another object of the invention is to provide a contaminant control system which enables stable operation of a plasma processing apparatus by controlling the number of generated contaminants and instructing a maintenance spot and a maintenance timing.

More specifically, according to one aspect of the invention, there is provided a method for processing a sample, comprising the steps of: supplying a process gas to

a processing chamber; generating plasma using a plasma generator; and processing the sample placed on a platform using the plasma; wherein, in the sample processing step, a space in the processing chamber except for a space defined between electrodes of the plasma generator or a portion above the platform in which the plasma is generated is irradiated with laser light for scanning; wherein scattered light from contaminants present in the processing chamber is detected; and wherein the contaminants are detected based on the detected scattered light.

In accordance with another aspect of the invention, there is provided an apparatus for processing a sample, comprising: a processing chamber provided with a platform on which the sample is placed, the processing chamber being provided with a measurement window formed on a wall surface; evacuation means for evacuating the processing chamber; gas injector for injecting a gas into the processing chamber; a plasma generator for generating plasma in the processing chamber after the processing chamber has been evacuated by the use of the evacuation means and the gas has been injected into the processing chamber by the use of the gas injector; and a particle detector for detecting scattered light generated from contaminants present in the processing chamber by irradiating and scanning, with laser light, a space which

is defined in the processing chamber but is outside a region where the plasma is generated via the measurement window during processing the sample placed on the platform with the plasma generated in the processing chamber by the use of the plasma generator.

In accordance with yet another aspect of the present invention, there is provided a plasma processing apparatus control system comprising: a plasma processing apparatus including a platform on which a sample is placed, a plasma generator, and a measurement window formed on a wall surface, the apparatus processing the sample placed on the platform with the plasma generated by the plasma generator; a particle detector for detecting scattered light generated from contaminants present in the plasma processing apparatus by irradiating and scanning, with laser light, a space which is defined in the processing apparatus but is outside a region where the plasma is generated via the measurement window of the processing apparatus during the plasma processing on the sample by the processing apparatus; and a controller for receiving a signal output from the processing apparatus and a detection signal from the particle detector to control the processing apparatus and contaminant data.

These and other objects, features, and advantages of the invention will be apparent from the following more

particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a sectional schematic view showing a position of attachment of a particle detector in a parallel plate type etching apparatus according to a first embodiment of the present invention.

Fig. 2 is a view illustrating an example of a laser scanning position of the particle detector according to the first embodiment of the invention.

Fig. 3 is a view showing a section taken along the line A-A' of Fig. 2.

Fig. 4 is a view illustrating another example of the laser scanning position of the particle detector according to the first embodiment of the invention.

Fig. 5 is a sectional schematic view showing a position of attachment of a particle detector in a parallel plate type etching apparatus according to a second embodiment of the invention.

Fig. 6 is a schematic view showing captured contaminants according to the second embodiment of the invention.

Fig. 7 is a schematic view showing captured contaminants according to the second embodiment of the

invention.

Fig. 8 is a schematic view showing captured contaminants according to the second embodiment of the invention.

Fig. 9 is a flowchart showing an operation of a processing apparatus according to a third embodiment of the invention.

Fig. 10 is a diagram illustrating an operation of a contaminant control system according to a fourth embodiment of the invention.

Fig. 11A and Fig. 11B are views illustrating a structure of a measurement window according to a fifth embodiment of the invention.

Fig. 12 is a view illustrating a position of a particle detector according to a sixth embodiment of the invention.

Fig. 13 is a view illustrating a position of a conventional particle detector.

Fig. 14 is a view illustrating a position of a conventional particle detector.

Description of the Preferred Embodiments

Hereinafter, embodiments of the present invention will be described in detail based on the drawings. In the drawings used for describing the embodiments, identical

component members are denoted by an identical reference numeral and repetitive description of such component members is omitted.

(First Embodiment)

In this embodiment, a particle detector which serves as an in-situ particle monitoring device for a parallel plate type plasma processing apparatus or a parallel plate type etching apparatus will be described as an example.

Fig. 1 is a sectional schematic showing a position of attachment of the particle detector in the parallel plate type etching apparatus according to this embodiment; Fig. 2 is a view illustrating an example of a laser scanning position of the particle detector according to this embodiment; Fig. 3 is a view showing a section taken along the line A-A' of Fig. 2; Fig. 4 is a view illustrating another example of the laser scanning position of the particle detector according to this embodiment.

Referring to Fig. 1, a processing chamber 1 is a vacuum reactor capable of achieving a vacuum of about 10^{-4}Pa and has an upper electrode 2 and a lower electrode 3. A gas supply port 5 for injecting a process gas 4 such as an etching gas is formed on the upper electrode 2, and a high frequency voltage from a radio frequency power supply 6 (RF power 13.56 MHz, for example) for generating plasma is applied to the upper electrode 2.

The lower electrode 3 has a structure such that a substrate 12 is mounted thereon and a bias control power supply 7 for controlling implanted ions is applied thereto.

The processing chamber 1 is continuously exhausted by the use of a turbo-molecular pump or the like through an exhaust passage 8, where an exhaust rate is adjusted by a butterfly valve 9.

A measurement window 10 for measurement is provided at an opening formed on a wall in a passage extending from the processing chamber 1 serving as the vacuum reactor to the exhaust passage 8. A particle detector 11 is provided in such a manner as to monitor floating contaminants generated in etching processing as well as in the processing chamber 1 through the measurement window 10.

An operation of this embodiment will hereinafter be described.

In the particle detector 11, laser light (the second harmonic of YAG: 532 nm, for example) is used for scanning the processing chamber using a scanner such as a galvano mirror.

The substrate 12 on which the etching processing is performed is disposed on the lower electrode 3. The process gas 4 is regulated to an arbitrary value by the use of an MFC (Mass Flow Controller) or the like, and a pressure in the processing chamber 1 is adjusted to an

arbitrary value such as a several Pa so that plasma is generated in the processing chamber 1 when the high frequency voltage is applied from the high frequency power supply 6 to the upper electrode 2.

An etching gas such as CF_4 and Cl_2 is used as the process gas 4, which is plasma-decomposed so that a thin film on the substrate 12 is etched by ions and neutral active species. During the etching, a process control is performed in such a manner that the particle detector 11 monitors contaminants generated during conveyance of the substrate 12 or plasma processing through the measurement window 10.

The particle detector 11 scans a laser scanning region 19 as shown in Figs. 2 and 3, for example, using the laser light with the laser scanning region 19 set in a direction orthogonal to the exhaust passage 18 (passage through which the gas flows) between the processing chamber 1 and the exhaust passage 8. That is to say, a section of a space where the contaminants are flowing is laser-scanned.

More specifically, the exhaust passage 18 above an exhaust port 20 is scanned for the laser scanning region 19 of the particle detector 11 to capture contaminants floating in the processing chamber 1. Further, scanning the laser scanning region 19 in a direction orthogonal to the gas flowing direction in the exhaust passage 18

increases a capture rate of contaminants flowing in or floating to the exhaust port 20. In addition, the laser scanning region 19 in a direction shown in Fig. 4 is effective based on the concept of orthogonal direction to the exhaust passage 18.

As described in the foregoing, the problems such as the reduction in contaminant capture rate and the deterioration in detection sensitivity due to fogging on the measurement window 10 have been encountered with the conventional examples wherein a particle detector 11c is provided in the exhaust passage 8 as shown in Fig. 13 and a particle detector 11b is provided at a position for observing the plasma generating space 13 above the substrate 12 as shown in Fig 14. However, the particle detector 11 is disposed on the exhaust passage 18 extending from the processing chamber 1 to the exhaust passage 8 in this embodiment as shown in Fig. 1, thereby improving the contaminant capture rate and enabling the contaminant detection with suppressed fogging on the measurement window 10 and without deterioration in the detection sensitivity.

(Second Embodiment)

In this embodiment, a particle detector which is an in-situ particle monitoring device for a microwave plasma etching apparatus will be described as an example.

Fig. 5 is a sectional schematic view showing a position of attachment of the particle detector in the parallel plate type etching apparatus according to the second embodiment, and Figs. 6 to 8 are schematic views each showing captured contaminants.

Referring to Fig. 5, the microwave plasma etching apparatus is such that an exhaust port 20 is provided beside a processing chamber 1 and the particle detector 11 is placed in an exhaust passage 18 extending from the processing chamber to the exhaust port 20. With the microwave plasma etching apparatus, a microwave is transmitted through a wave guide 21 to generate plasma above a platform 14 in the processing chamber 1 via a quartz plate 22, and the plasma is controlled by an electromagnet 23 provided around the processing chamber 1.

For the processing apparatus where the electromagnet 23 is provided around the processing chamber 1, a measurement window 10 for the particle detector 11 formed in the plasma generating space 13 might influence on a plasma generation state. As described in the foregoing, etching on the measurement window 10 progresses due to film deposition caused by reaction products and etchant when the measurement window 10 is exposed to the plasma generation space 13, which causes fogging on the measurement window 10 to deteriorate detection sensitivity.

In this embodiment, by providing the particle detector 11 in the exhaust passage 18 extending from the processing chamber 1 to the exhaust port 20 as shown in Fig. 5, contaminants can be measured without exposing the measurement window 10 to the high density plasma generating space 13.

Further, with such installation position of the particle detector 11 of this embodiment, a laser scanning region is set in such a manner that a scanned surface is orthogonal to a horizontal direction of the exhaust passage 18 extending from the processing chamber 1 to the exhaust port 20, thereby capturing contaminants flowing in the exhaust stream and contaminants floating in the processing chamber 1.

Hereinafter, a state of capturing contaminants of this embodiment will be described.

Contaminants 24 flowing from the processing chamber 1 to the exhaust port 20 are captured through the laser scanning region 19 in the exhaust passage 18.

Since the contaminants 24 float irrelevant from the flow of the gas under a high vacuum of about a several Pa, it is important to capture the contaminants 24 at the time when the contaminants are floating, such as a trigger application time including introduction of a process gas and a start and a stop of a plasma discharge, so as to

grasp a contaminant generating state in the processing chamber 1.

Owing to the position of the particle detector 11 and the laser scanning method according to this embodiment, probability of detecting the contaminants 24 is high even if the contaminants fallen in the processing chamber do not float upward to reach to the platform 14 as shown in Fig. 6.

Since the particle detector is placed between the exhaust port 20 and the processing chamber 1, it is possible to capture contaminants derived from a butterfly valve 9 before they reach to the platform 14, thereby enabling early detection of contaminants occurrence in the processing chamber 1 caused by the apparatus.

It is possible to obtain information on scattered light generation position in the vertical direction as data owing to the laser scanning, thereby making it possible to distinguish among contaminants floating from the bottom in the processing chamber 1, contaminants fallen from a cover of the exhaust port 20 and an inner wall of the processing chamber 1, and contaminants flowing from a conveyance room when the substrate 12 was loaded.

(Third Embodiment)

An operation of a processing apparatus provided with the particle detector 11, such as the parallel plate type

etching apparatus and the microwave plasma etching apparatus described in the first and the second embodiment, is described in this embodiment.

Fig. 9 is a flowchart showing the operation of the processing apparatus according to the third embodiment.

The processing apparatus such as the parallel plate type etching apparatus and the microwave plasma etching apparatus has the particle detector 11 which is provided in the exhaust passage 18 from the processing chamber 1 to the exhaust passage 8 as described in the first and the second embodiment, and contaminants are continuously detected during the operation of the processing apparatus.

When the processing apparatus is in operation, a wet cleaning or the like is performed for apparatus maintenance (S100) and then aging or an in-situ plasma cleaning is performed (S101). The step S101 is repeated until the number of contaminants is below a control standard of the contaminant detection which is performed continuously by the particle detector 11 (S102).

When the number of contaminants is below the control standard in S102, the processing apparatus starts various pieces of processing (S103). If the number of contaminants is below the control standard in the continuous contaminant detection performed by the particle detector 11, the process returns to S103 so that the processing is continued

(S104).

When the number of contaminants is above the control standard in S104, a maintenance method is decided depending on a contaminant detection state (S105). When a maintenance A for performing the wet cleaning is decided in S105, the process returns to S100. When a maintenance B for performing the in-situ plasma cleaning is decided in S105, the process returns to S101 so that the rest of the processing is performed.

Thus, the particle detector 11 placed in the exhaust passage 18 from the processing chamber 1 to the exhaust passage 8 detects the contaminants continuously during the operation of the processing apparatus. Thus, the contaminant detection can be performed without fail and the maintenances during the operation of the processing apparatus can be properly performed.

(Fourth Embodiment)

In this embodiment, an operation of a contaminant control system using the processing apparatus provided with the particle detector 11, such as the parallel plate type etching apparatus and the microwave plasma etching apparatus as described in the first and the second embodiment, will be described.

Fig. 10 is a diagram illustrating the operation of

the contaminant control system according to this embodiment.

Referring to Fig. 10, the contaminant control system has a plasma processing apparatus control system 50 and a contaminant detection system 51 such that a contaminant generation state in the processing apparatus is controlled according to the number of contaminants detected by the particle detector 11.

A graph included in Fig. 10 shows an example of a fluctuation with measurement time in the number of contaminants, illustrating an operation state of the processing apparatus associated with the fluctuation.

When contaminants are increased in number, an instruction of wet cleaning is given from the contaminant control system so that the vacuum processing apparatus is opened to the air and the wet cleaning is performed for apparatus maintenance (S1).

At the time when predetermined vacuum and temperature are reached, an aging step is performed to stabilize an atmosphere inside the apparatus while monitoring the reduction in the number of contaminants.

Then, upon performing a plasma etching process step (S3), an instruction of cleaning is given from the contaminant control system when the number of contaminants exceeds the contaminant control standard.

Since the state shown in the example of Fig. 10 is

of below the contaminant control standard, a wafer is conveyed (S4). A contaminant measurement is performed during the wafer conveyance operation of the processing apparatus (S4). When the number of contaminants exceeds the control standard, the operation mechanisms of the processing apparatus during the conveyance, i.e., the gate valve opening/closing, and an arm conveyance chamber are supposed to be contaminant sources, so that the contaminant control system gives the instruction of cleaning.

Since the number of contaminants is below the contaminant control standard during the wafer conveyance operation in the example shown in Fig. 10, the instruction of cleaning is not given but it is possible to detect the contaminant source by repeating the apparatus operation and to perform a contaminant countermeasure against the detected contaminant source.

The number of contaminants exceeds the contaminant control standard when the plasma etching process is performed (S5), and accordingly the contaminant control system gives an instruction of cleaning to perform the in-situ cleaning by plasma cleaning (S6).

The contaminant measurement is continued even during the in-situ cleaning by plasma cleaning, while the contaminant control system gives an instruction of starting an etching process (S7). Thus, the contaminant control

system measures the fluctuation in the number of contaminants and instructs the start of cleaning and the start of plasma processing.

The cleaning instruction is changed between the in-situ plasma cleaning instruction and the wet cleaning instruction depending on the contaminant generation state.

In the contaminant occurrence (1) shown in Fig. 10, when the number of contaminants continuously increases and the scattered light intensity is constant, fine contaminants have occurred; therefore, it is estimated that the contaminants were generated when a thin film deposited on an inner wall of the processing chamber 1 was etched. Accordingly, the in-situ plasma cleansing is performed to remove the deposited film.

In the contaminant occurrence (2) shown in Fig. 10, the scattered light intensity increases although the number of contaminants does not increase rapidly. In this case, it is highly probable that an amount of film deposited on the inner wall of the processing chamber 1 is great and large contaminants float due to stripping of the deposited film. Therefore, a maintenance to be made is the wet cleaning. In the contaminant occurrence (2), a case wherein not only the scattered light intensity but also the number of contaminants possibly increases will occur.

An operation state of the processing apparatus is

checked with the decision on the cleaning method simultaneously when the decision on the cleaning method is made (S8) such that a contaminant occurrence spot is identified (S9). Responding to the results, the contaminant control system gives instructions on the corresponding maintenance method and spot (S10).

In this embodiment, the contaminant control system performs the contaminant measurement when the processing apparatus is operated and gives the instructions on maintenance method and spot depending on the contaminant measurements and the operation state of the processing apparatus, thereby performing the proper maintenance to realize the stable operation of the processing apparatus.

(Fifth Embodiment)

In this embodiment, a measurement window 10 has the shape of a slit and fogging on the measurement window 10 is suppressed.

Figs. 11A and 11B are a sectional view and a plane view showing a structure of the measurement window according to the fifth embodiment, respectively.

A particle detector 11 is disposed in an exhaust passage 18. This permits a long-term stable particle monitoring as described in the foregoing. Since the particle detector 11 detects particles having the size of

from a several microns to a submicron order, film deposition on the measurement window 10 caused by the etching processing and fogging on the measurement window 10 due to etching influence greatly on detection sensitivity.

In particular, scattered light from particles having a diameter of 0.25 μm or less is in the Rayleigh scattering region and intensity of the scattered light is inverse proportion to the sixth power of particle diameter. Therefore, the fogging on the measurement window 10 is crucial for detection of fine particles. That is to say, the sensitivity for detecting particles can be deteriorated to a large extent due to the fogging on the measurement window 10 irrelevant from the excellent sensitivity of the particle detector 11. A change with time of the detection sensitivity is increased particularly when the measurement window 10 is exposed to plasma.

In terms of the above problems, this embodiment enables to reduce the amount of reaction products generated due to plasma and the amount of etchant arriving at the measurement window 10 by placing the particle detector 11 not on the position between the electrodes or the platform but on the space which is remote from the plasma generating space 13 and is between the processing chamber 1 and the exhaust passage 8. Further, it is possible to stably detect fine signals generated from the fine particles.

Also, in this embodiment, in order to further reduce the amounts of the reaction products and etchant reaching to the measurement window 10, the measurement window 10 has the slit-like shape as shown in Fig. 11A.

A vacuum of the etching processing is about a several Pa which is under a low pressure condition and a mean free path λ of molecules is about a several millimeters (in the case of Ar molecules at 25°C). Therefore, a passage 29 extending from the processing chamber 1 is formed in such a manner that a height thereof is equal to or shorter than the mean free path and a length thereof (directed from the processing chamber 1 to the measurement window 10) is equal to or longer than the mean free path.

Thus, the molecules adhere to an inner wall of the slit with a probability higher than that with which the molecules reach to the measurement window. Accordingly, owing to this proper slit dimension, the probability of the reaction products and the etchant reaching to the window 25 can be reduced. In order to enhance this effect, it is desirable to reduce a height and a width of the slit as much as possible and to increase a length of the slit in a depth direction as much as possible.

Thus, the particle detector 11 is placed on the position remote from the plasma generating space 13, and

the fogging on the window 25 is suppressed by reducing the probability of the reaction products and the etchant reaching to the window 25. As a result, the change with time of the window 25 due to plasma is suppressed, and the stable, highly accurate monitoring is achieved.

Also, in order to prevent the microwave from leaking to the measurement window 10, it is desirable to use a transparent electroconductive film. More specifically, the window 25 which is a transparent member made from glass or a sapphire substrate is coated with a transparent electroconductive film 26 such as ITO (indium tin oxide) or ZnO (zinc oxide) to form the measurement window 10 attached to the plasma processing apparatus.

The coating surface is on the outer surface of the plasma processing apparatus, i.e., faces to the monitoring side, but a surface facing to the interior of the processing chamber 1 is a clean surface without coating. The thus-obtained measurement window 10 has a transparency of 80% transmittivity or more in the visual area and is capable of maintaining the detection sensitivity of an optical monitoring device such as a particle monitor.

The coating film has a resistance of 10^{-4} $\Omega \cdot cm$ or less and serves as an electroconductive part. This coating film is connected to the plasma processing apparatus to make a potential of the coating film and that of the plasma

processing apparatus to be identical, which prevents the electromagnetic wave from leaking from the plasma generating space 13 and from influencing on the sensor and the human body.

The window 25 should have a thickness and material enough to endure a high vacuum (at least 10^{-4} Pa). For this purpose, the window 25 is fixed to the measurement window 10 using an O-ring 27. The material of the window 25 is selected depending on a measurement wavelength range. In order to further avoid the etching due to the chemical reaction of the etchant in the plasma processing, a sapphire glass which well endures the etching is favorably used for the window 25.

Also, in this embodiment, it is desirable to subject the window 25 to a low reflection surface coating such as a black alumite processing so as to prevent the scattered light caused by the laser light reflecting from the inner wall of the measurement window 10 from influencing on the detection. In order to prevent the reflection of the laser light from influencing on the detection, the window 25 is provided with a reflection prevention film 28 which is formed on the transparent electroconductive film 26 at the laser incident side.

Also, the particle detector 11 of the invention is provided in an optical detection system with a space filter

for shielding the reflected light from the inner wall of the processing chamber to suppress influences of the reflected light on the detection.

(Sixth Embodiment)

In this embodiment, a particle detector 11 is so disposed as not to be orthogonal to an inner wall of a vacuum processing apparatus which is irradiated with laser light 15, thereby avoiding intense reflected light from a wall opposite the particle detector 11.

Fig. 12 is a view illustrating the position of the particle detector according to the sixth embodiment, wherein a section taken along the line B-B' is shown.

Since the position of the particle detector 11 is less influential to plasma generation, it is possible to change the position of the particle detector 11 depending on optical characteristics and the shape of a processing chamber 1 which is irradiated with the laser light.

For example, as shown in Fig. 12, the particle detector 11 is so disposed as not to be orthogonal to the vacuum processing apparatus inner wall 31 which is irradiated with the laser light 15. Alternatively, the shape of an inner wall of the particle detector 11 can be so changed as not be orthogonal to the vacuum processing apparatus inner wall 31.

With the above constitution, it is possible to avoid the intense reflected light from the wall opposite the particle detector 11 and to guide the reflected light 30 not to the particle detector 11 but to another direction.

Also, in the case where the inner wall of the processing chamber 1 is made from a high reflection material such as stainless and aluminum, the following stray light countermeasures may be taken: performing black alumite processing on a laser irradiation portion of the inner wall; and use of a material absorbing the laser light wavelength for forming the laser irradiation portion.

In addition, although the first to sixth embodiments are directed to the etching process, it is possible to apply the contaminant detection method of the invention to processes such as sputtering and plasma CVD.

Also, although the first to sixth embodiments are described by taking the example of the in-situ particle detector using backward scattered light, the invention is not limited thereto. The same effect is achieved in photodetection methods using forward scattered light or laterally scattered light, although a plurality of windows are required.

As described in the foregoing, according to the invention, the particle detector is placed for measurement between the electrodes in the plasma processing apparatus,

i.e., in the processing chamber for generating plasma other than the portion on the platform, such as a space defined between the processing chamber and the exhaust passage. As a result, the fogging on the measurement window can be suppressed, and accordingly floating contaminants in the processing chamber can be detected stably, leading to improvement in the contaminant capture rate.

Also, according to the invention, the contaminant control system gives instructions on the maintenance spot, time, and method, thereby enabling the plasma processing apparatus to perform stable operation.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.